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Monitoring Study of Urinary Metabolites and Selected Symptomatology Among Florida Citrus Workers

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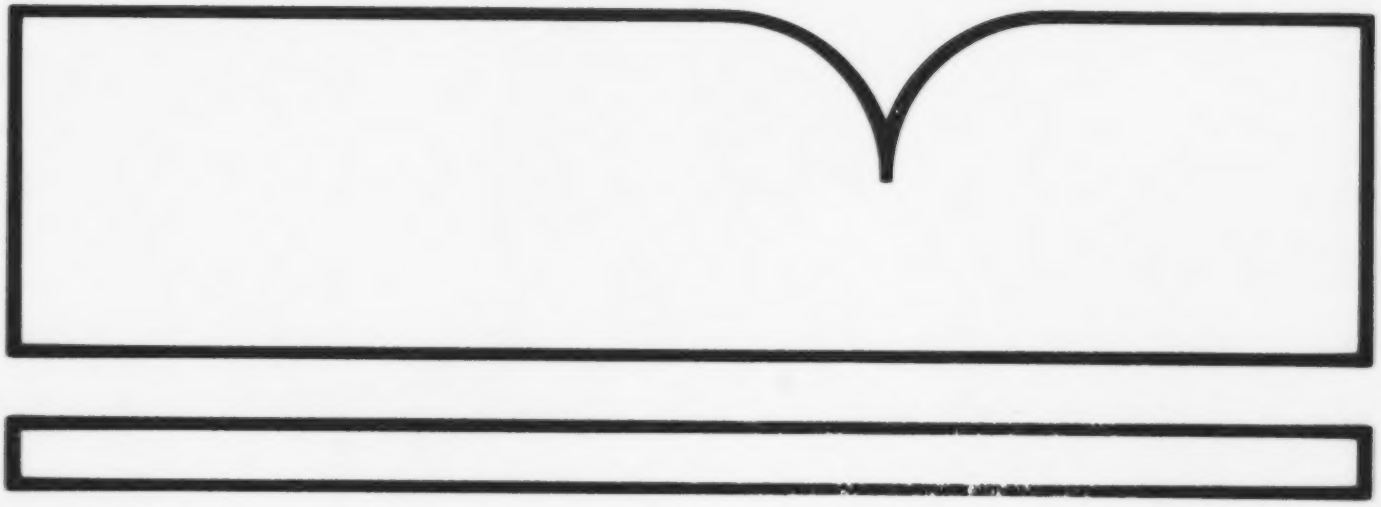

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16. ABSTRACT

A cross-sectional monitoring study was made of citrus fieldworkers employed during an entire citrus growing season in Florida. A survey questionnaire was administered to 1811 fieldworkers employed as applicators, mixers, loaders, tractor drivers, general combination workers, and pickers on 436 citrus groves throughout Florida. The study was designed to evaluate exposure to organophosphorus pesticides by analyzing the urine of citrus fieldworkers for dimethyl phosphate (DMP), dimethyl thiophosphate (DMTP), dimethyl dithiophosphate (DMDTP), diethyl phosphate (DEP), diethyl thiophosphate (DEPT), and diethyl dithiophosphate (DEDTP), and to relate the findings to the reported occurrence of selected health symptoms associated with pesticide intoxication. Urine samples were collected for analysis from 332 spray-season workers and 265 harvest-season workers. Measurable DEP residue values were found in 68% of the spray season workers and 43% of the harvesters. However, with the exception of DEP and DETP values in the urine of spray-season workers, metabolite residues were low, often at, or just above, detection limits (which were usually 0.02 ppm but occasionally rose higher, with a few at 0.03 ppm and a very few at 0.04 ppm). Although there was clearly exposure to organophosphates among the citrus fieldworkers, there was no apparent association between the reported health symptoms and the relatively low levels of organophosphate metabolities found in the urine of the workers.

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MONITORING STUDY OF URINARY METABOLITES AND SELECTED SYMPTOMATOLOGY AMONG FLORIDA CITRUS WORKERS

R. C. Duncan

The University of Miami School of Medicine,
Department of Oncology, Miami, Florida

J. Griffith

U. S. Environmental Protection Agency,
Health Effects Research Laboratory,
Research Triangle Park, North Carolina

A cross-sectional monitoring study was made of citrus fieldworkers employed during an entire citrus growing season in Florida. A survey questionnaire was administered to 1811 fieldworkers employed as applicators, mixers, loaders, tractor drivers, general combination workers, and pickers on 436 citrus groves throughout Florida. The study was designed to evaluate exposure to organophosphorus pesticides by analyzing the urine of citrus fieldworkers for dimethyl phosphate (DMP), dimethyl thiophosphate (DMTP), dimethyl dithiophosphate (DMDTP), diethyl phosphate (DEP), diethyl thiophosphate (DEPT), and diethyl dithiophosphate (DEDTP), and to relate the findings to the reported occurrence of selected health symptoms associated with pesticide intoxication. Urine samples were collected for analysis from 332 spray-season workers and 265 harvest-season workers.

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Requests for reprints should be sent to Jack Griffith, U. S. Environmental Protection Agency, Health Effects Research Laboratory (MD-55A), Research Triangle Park, North Carolina 27711.

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INTRODUCTION

The maintenance of groves and the harvesting of citrus requires large numbers of workers who frequently work for more than one employer and on many different groves. Fieldworkers may be exposed to organophosphorus pesticides (OPs) by three principal routes: inhalation, ingestion, and skin (Kilgore and Akesson, 1980). OPs applied to foliage can dissipate through volatilization, creating air concentrations that the workers may breathe and to which workers may be exposed by ingesting food crops covered with pesticide residues (Milby et al., 1964). The most common means of exposure, and the one of most concern to health scientists, is dermal exposure from foliar residues (Popendorf et al., 1979). There is concern that dermal exposure, usually measured in hours, but at times accumulating over a period of several weeks, may lead to significant acute health risks for fieldworkers (Spear et al., 1975; Popendorf et al., 1976). Acute illness, characterized by systemic symptoms) e.g., nausea, vomiting—and/or topical symptoms—e.g., conjunctivitis, dizziness—has been described elsewhere (W. H. Hayes, Jr., et al., 1957; Sumerford et al., 1953).

Acute illness resulting from OP exposure occurs among all occupational categories of fieldworkers. As characterized by Davies et al. (1976), single workers or small groups of workers with the most direct exposure to the OP (e.g., mixers, loaders, and applicators) generally experience the most severe illnesses, often requiring hospitalization. However, severe illness has also been reported among large numbers of California pickers during reentry (Maddy, 1976). In general, however, fieldworkers with a more indirect exposure to OPs, such as pickers, thinners, and irrigators, experience less severe illness than their more exposed colleagues. Illness reported by these workers is often characterized by self-described, nonspecific symptoms, similar to those described by Milby et al. (1964) during an investigation of 45 California peach pickers and by Tabershaw and Cooper (1966) in their study of 114 workers occupationally exposed to OPs.

Attempts have been made to estimate worker exposure by measuring concentrations of pesticide residues on foliar and soil samples, workers clothing (including gloves, shirts, and coveralls), in air samplers strategically placed in and around treated fields, and on absorbent pads placed on the person of the worker. However, extrapolation to the worker has been difficult and the results have been inconclusive. For example, Milby et al. (1964) and G. R. Hayes, Jr., et al. (1964) found it difficult to determine the amount of pesticide residue actually reaching the surface of the skin through clothing or other protective material. It is also difficult to measure the actual absorption of a pesticide through the skin (Maibach et al., 1971; Ware and Morgan, 1976).

Cholinesterase (ChE) determinations have been used to detect excessive OP exposure. However, a significant decrease in ChE activity

requires high levels of OP exposure (Shafik and Bradway, 1976), thus presumably increasing risk to the worker. In addition, depressed ChE values do not always reflect symptomatic illness (Milby et al., 1964). Further, enzyme determination requires an invasive procedure that inhibits participation by fieldworkers (Krause et al., 1981) and makes it difficult to use the technique in a monitoring mode on large number of fieldworkers (Davies et al., 1976). Analytical techniques developed by Shafik et al. (1973) to determine alkyl phosphate metabolites in urine now provide an effective mechanism for measuring human occupational exposure to OP pesticides (Davies et al., 1976). Dimethyl phosphate (DMP), dimethyl thiophosphate (DMTP), dimethyl dithiophosphate (DMDTP), diethyl phosphate (DEP), diethyl thiophosphate (DETP), and diethyl dithiophosphate (DEDTP) are the primary dialkyl phosphate urinary metabolites resulting from OP exposure.

Although the dialkyl phosphate metabolites are not chemically specific, they do provide a means of limiting the possibilities and of quantifying absorption in a more meaningful way. For example, Davies et al. (1976) have characterized pesticide loaders and spray pilots occupationally exposed to a variety of OPs as typical of high and low exposure, with respective urinary metabolite mean values in ppm as shown: DEP (0.48, 0.26); DETP (0.49, 0.11); DMP (0.25, 0.06); and DMTP (0.09, not detected).

The purpose of the current study was to monitor a large number of spray- and harvest-season citrus fieldworkers utilizing techniques similar to those of Knaak et al. (1977) in order to determine urinary metabolite levels, characterize occupational exposure to OPs, and relate the findings to selected health symptoms.

METHODS

Although a cross-sectional approach makes it impossible to establish an exposure-disease time sequence, such data are more likely to be collected in an occupational setting (Monson, 1980). However, since we were less interested in the disease time sequence than in developing point-in-time data and disease rates between exposed and nonexposed citrus workers, we elected to use the cross-sectional approach. Data for the study are based on a statistical sample, described elsewhere (Griffith and Duncan, 1985a), of 436 citrus growers and 1811 fieldworkers employed during one complete spray and harvest citrus growing season.

A citrus fieldworker was defined as a male or female who worked for a grower and was involved in either the growing or harvesting of citrus. In attempting to measure pesticide exposure and absorption, we recruited a randomly selected study population by seasonal employment: 1200 spray-season workers during the actual application period when they would most likely be exposed, and 611 pickers during the harvest season when any application of pesticides is highly restricted and therefore presents the least likelihood of exposure.

Spray-season workers included permanent and semipermanent workers involved in pesticide mixing, loading, and application activities, as well as workers engaged in grove maintenance. Harvest-season workers were temporary and highly transient, moving from grove to grove, primarily involved in picking fruit.

Shafik and Enos (1969) developed a method of determining urinary metabolites of organic phosphorus insecticides at concentrations ordinarily found in people unexposed to the OP compounds. Therefore, during the spray season a subsample of 332 workers was identified as being employed on a randomly selected subsample of citrus groves in the overall sample, and the workers were interviewed and urine collected at that site. During the harvest season, picking crews were often found to be associated with more than one grove; consequently, a subsample of 265 workers was interviewed and urine collected at the most convenient sampled site. In total, we interviewed 1811 fieldworkers by closed-ended questionnaire, and monitored the urinary dialkyl phosphate excretion of 597 fieldworkers throughout the state of Florida. Urine was analyzed for DEP, DETP, DMP, DMTP, DMDTP, and DEDTP.

Since our objective was to monitor for OP exposure by measuring metabolites in workers expected to have sporadic, rather than constant, exposure to OPs, and since we were not interested in developing excretion rates, we elected to follow the suggestion of W. J. Hayes (1975) and use an approach similar to that of Davies et al. (1980) and Kilgore et al. (1977). Participating workers were provided with a washed and hexane-rinsed laboratory specimen bottle at the start of the work day, and the urine sample was collected at the end of the work day. The methods of collection and analysis are described elsewhere (Griffith and Duncan, 1985b). To adjust for varying urine concentrations, brought about by dilution (water intake and the kidney's ability to concentrate), dosage, and time since last exposure, residue levels were corrected for osmolality. Spiked urine samples and reagent blanks were used to monitor for interfering components daily. Analyses were performed using the method by Lores and Bradway (1977). Although it is recognized that the percentage of recovery of the metabolites using this method may vary, and, as reported, may present a low recovery for DMTP (39%), which apparently is due to the diazopentane reagent, the purpose of this paper is to compare differential levels with the presence or absence of symptomatology, and this comparison would not be expected to be affected by recovery levels. This method provided a rapid (minimum of 8-10 samples/d) and sensitive (below 0.1 ppm) procedure that enabled us to monitor a large number (597) of fieldworkers for urinary alkyl phosphate metabolites. Detection limits were usually at 0.02 ppm but occasionally rose higher, with a few at 0.03 ppm and a very few at 0.04 ppm. The workers were paid a nominal fee when the samples were taken. Samples sent from the field via courier were analyzed by staff of the University of Miami National Pesticide Hazard Assessment Project (NPHAP).

To encourage participation of the workers and completion of field activities, field coordinators and interviewers were local people residing in the survey area and familiar with the local citrus industry. Each worker was queried concerning his or her most recent exposure to pesticides. Questions centered on time and method of the most recent exposure opportunity. The workers were also queried on the occurrence, within 2 wk of the interview date, of any of the following symptoms: disorientation, dizziness, excitability, convulsions, muscle twitching, muscle tremor, muscle weakness, conjunctivitis, blurred and/or dark vision, and excessive sweating. Dialkyl phosphate residues were correlated with the presence or absence of each of these symptoms. The statistical treatment of the pesticide residue values is described elsewhere (Griffith and Duncan, 1985c). Student's *t*-test was utilized when appropriate. No statistical test was reported when the sample mean was not equal to or greater than twice the sample standard error or was based on less than three observations. When statistical analyses called for a one-degree-of-freedom chi-square test, all tests used the Yates correction factor, and Fisher's exact probability test was used when called for by small expected values. Overall mean dialykl phosphate values and percentage of detectables among Florida citrus fieldworkers for DMP, DMTP, DMDTP, DEP, DETP, and DEDTP are reported elsewhere (Griffith and Duncan, 1985b).

RESULTS

Almost 79% (1422) of the fieldworkers did not know when they were last exposed to pesticides, while 130 (7.2%) reported that the most recent exposure was the day before the interview, and 259 (14.3%) said that exposure took place from 1 wk to 1 mo prior to the interview. Almost 700 (38.3%) of the fieldworkers reported that their last pesticide exposure was during the mixing, loading, and application of pesticides.

Among the spray-season workers, 50 (4.2%) identified themselves as mixers, loaders, or applicators, while 1150 (95.8%) reported they were employed as fieldhands involved in a combination of activities from pesticide application to irrigation. Among the harvest-season workers, 564 (92.3%) identified themselves as pickers, while 47 (7.7%) reported they were employed as fieldhands involved in a combination of activities from tractor driving to pruning.

As shown in Table 1, six dialkyl phosphates (DMP, DMTP, DMDTP, DEP, DETP, DEDTP) were detected in the urine of the spray- and harvest-season workers. The data show the mean values by selected symptom for each of the urinary metabolites for symptomatic and asymptomatic workers. The mean levels of DMP, DMTP, DMDTP, and DEDTP by selected symptoms were generally well below the DEP and DETP levels found in spray-season workers. These metabolites were generally of the same levels as the DEP and DETP levels found in the harvest-season

TABLE 1. Urine Alkyl Phosphate Metabolite Residue Values and Selected Symptoms among Spray and Harvest Fieldworkers

Selected health symptoms	DMP						DMTP						DMDTP					
	Spray season			Harvest season			Spray season			Harvest season			Spray season			Harvest season		
	$N = 332$	Mean value[a] (ppm)	SD	$N = 264$	Mean value (ppm)	SD	$N = 323$	Mean value (ppm)	SD	$N = 262$	Mean value (ppm)	SD	$N = 331$	Mean value (ppm)	SD	$N = 265$	Mean value (ppm)	SD
Disorientation																		
Yes	6	0.117	0.080	1	1.070	—[b]	2	0.035	0.021	1	0.160	—	0	—	—	1	1.90	—
No	154	0.164	0.453	15	0.348	0.797	55	0.084	0.126	9	0.144	0.280	23	0.106	0.116	17	0.155	0.183
Dizziness																		
Yes	13	0.267	0.475	2	0.615	0.643	4	0.145	0.230	2	0.105	0.078	3	0.153	0.204	2	0.985	1.294
No	147	0.153	0.442	14	0.361	0.826	53	0.077	0.116	8	0.156	0.297	20	0.099	0.103	16	0.160	0.187
Excitability																		
Yes	12	0.256	0.497	1	0.610	—	3	0.182	0.267	1	0.040	—	2	0.236	0.218	3	0.143	0.110
No	148	0.154	0.441	15	0.379	0.817	54	0.067	0.114	9	0.158	0.277	21	0.094	0.104	15	0.273	0.489
Convulsions																		
Yes	0	—	—	0	—	—	0	—	—	0	—	—	0	—	—	1	0.090	—
No	160	0.162	0.444	16	0.393	0.791	57	0.082	0.125	10	0.146	0.264	23	0.106	0.116	17	0.261	0.460
Muscle twitching																		
Yes	14	0.223	0.470	1	0.160	—	5	0.121	0.206	1	0.050	—	4	0.148	0.164	2	0.080	0.014
No	146	0.156	0.443	15	0.409	0.816	52	0.078	0.116	9	0.157	0.278	19	0.097	0.110	16	0.273	0.472
Muscle tremor																		
Yes	8	0.115	0.188	1	3.180	—	3	0.030	0.010	1	0.890	—	2	0.060	0.042	2	0.190	0.141
No	152	0.165	0.454	15	0.207	0.281	54	0.085	0.128	9	0.063	0.040	21	0.110	0.124	16	0.259	0.474
Muscle weakness																		
Yes	8	0.082	0.032	0	—	—	3	0.029	0.009	0	—	—	1	0.082	—	0	—	—
No	152	0.166	0.455	16	0.393	0.791	54	0.085	0.127	10	0.146	0.264	22	0.107	0.112	18	0.252	0.448
Conjunctivitis																		
Yes	4	0.243	0.238	1	0.610	—	2	0.020	0.00	2	0.030	0.014	1	0.030	—	3	0.170	0.092
No	156	0.160	0.449	15	0.379	0.817	55	0.084	0.126	8	0.175	0.291	22	0.109	0.112	15	0.268	0.491

Blurred and/or dark vision																		
Yes	11	0.154	0.155	3	0.613	0.455	5	0.030	0.012	4	0.068	0.063	1	0.030	—	3	0.747	1.004
No	149	0.163	0.459	13	0.342	0.856	52	0.086	0.130	6	0.198	0.339	22	0.109	0.117	15	0.153	0.192
Excessive sweating																		
Yes	15	0.144	0.321	4	1.003	1.471	6	0.163	0.313	4	0.265	0.417	3	0.103	0.027	5	0.146	0.124
No	145	0.164	0.456	12	0.190	0.289	51	0.072	0.082	6	0.067	0.049	20	0.107	0.122	13	0.292	0.522

	DEP						DETP						DEDTP					
	Spray season			Harvest season			Spray season			Harvest season			Spray season			Harvest season		
Selected health symptoms	N = 332	Mean value[a] (ppm)	SD	N = 265	Mean value (ppm)	SD	N = 321	Mean value (ppm)	SD	N = 262	Mean value (ppm)	SD	N = 331	Mean value (ppm)	SD	N = 262	Mean value (ppm)	SD
Disorientation																		
Yes	8	0.164	0.174	9	1.131	0.156	5	0.102	0.083	4	0.063	0.052	3	0.116	0.083	1	0.040	—
No	220	0.414	1.050	105	0.083	0.067	105	0.380	0.848	65	0.065	0.054	73	0.247	0.509	13	0.059	0.022
Dizziness																		
Yes	16	0.502	1.102	8	0.131	0.165	9	0.301	0.394	5	0.050	0.025	6	0.143	0.169	0	—	—
No	12	0.398	1.029	106	0.083	0.067	101	0.374	0.860	64	0.066	0.055	70	0.250	0.518	14	0.058	0.022
Excitability																		
Yes	16	0.238	0.375	14	0.074	0.038	10	0.221	0.300	6	0.075	0.042	4	0.143	0.152	2	0.039	0.002
No	212	0.418	1.065	100	0.088	0.082	100	0.382	0.866	63	0.064	0.054	72	0.247	0.512	12	0.061	0.022
Convulsions																		
Yes	0	—	—	2	0.090	0.057	0	—	—	1	0.080	—	0	—	—	0	—	—
No	228	0.405	1.032	112	0.086	0.078	110	0.368	0.831	68	0.065	0.053	76	0.242	0.499	14	0.058	0.022
Muscle twitching																		
Yes	19	0.294	0.542	10	0.114	0.140	8	0.270	0.323	5	0.093	0.048	6	0.362	0.520	1	0.062	—
No	209	0.416	1.066	104	0.084	0.070	102	0.375	0.858	64	0.063	0.053	70	0.232	0.500	13	0.058	0.022
Muscle tremor																		
Yes	9	0.461	0.733	9	0.129	0.145	5	0.214	0.235	3	0.097	0.067	5	0.418	0.560	1	0.040	—
No	219	0.403	1.044	105	0.083	0.069	105	0.375	0.848	66	0.064	0.053	71	0.230	0.497	13	0.059	0.022

(Footnotes on p. 516.)

TABLE 1. Urine Alkyl Phosphate Metabolite Residue Values and Selected Symptoms among Spray and Harvest Fieldworkers *(Continued.)*

Selected health symptoms	DEP						DETP						DEDTP					
	Spray season			Harvest season			Spray season			Harvest season			Spray season			Harvest season		
	$N = 332$	Mean value[a] (ppm)	SD	$N = 265$	Mean value (ppm)	SD	$N = 321$	Mean value (ppm)	SD	$N = 262$	Mean value (ppm)	SD	$N = 331$	Mean value (ppm)	SD	$N = 262$	Mean value (ppm)	SD
Muscle weakness																		
Yes	8	0.094	0.087	7	0.081	0.049	2	0.080	0.029	4	0.068	0.049	2	0.113	0.067	0	—	—
No	220	0.417	1.049	107	0.087	0.079	108	0.373	0.837	65	0.065	0.054	74	0.245	0.506	14	0.058	0.022
Conjunctivitis																		
Yes	7	0.584	0.761	10	0.071	0.036	5	0.240	0.252	3	0.060	0.036	3	0.280	0.233	0	—	—
No	221	0.400	1.041	104	0.088	0.081	105	0.374	0.848	66	0.065	0.054	73	0.240	0.508	14	0.058	0.022
Blurred and/or dark vision	14	0.326	0.584	13	0.108	0.132	5	0.248	0.244	7	0.054	0.021	6	0.176	0.188	0	—	—
Yes	214	0.411	1.056	101	0.084	0.068	105	0.373	0.849	62	0.066	0.055	70	0.248	0.518	14	0.058	0.022
No																		
Excessive sweating	19	0.128	0.131	22	0.075	0.035	5	0.214	0.235	1	0.080	—	5	0.067	0.065	1	0.090	—
Yes	209	0.431	1.074	92	0.089	0.085	105	0.375	0.848	68	0.065	0.053	71	0.254	0.514	13	0.056	0.020
No																		

[a] Number of workers with residues above trace levels.
[b] Indicates asymptomatic workers.

workers. Based on the numbers of workers with residues above trace levels, it is clear that the spray-season workers are more exposed than the harvesters. The mean values for DMP range from a high of 3.20 ppm among harvesters reporting muscle tremor, to 0.08 ppm among spray-season workers with muscle weakness. There were no spray- or harvest-season workers with DMP values reporting convulsions, and no harvest-season workers reporting muscle weakness. The high value for disorientation and muscle tremor represented only one harvest-season worker. The value for excessive sweating represented four harvest-season workers.

The mean values for DMTP range from a high of 0.89 ppm among harvesters reporting muscle tremor to a low of 0.02 ppm among spray-season workers reporting conjunctivitis. There were no spray- or harvest-season workers with DMTP values reporting convulsions, and no harvest-season workers reporting muscle weakness. The high value represented only one harvest-season worker.

The mean values for DMDTP range from a high of 1.90 ppm among harvesters reporting disorientation to a low of 0.03 ppm among spray-season workers reporting conjunctivitis. There were no spray-season workers with DMDTP values reporting convulsions and disorientation, and no harvest-season workers reporting muscle weakness. The high and low values represented only one harvest- and spray-season worker, respectively.

The mean values for DEP range from a high of 0.58 ppm among spray-season workers reporting conjunctivitis to a low of 0.07 ppm among harvesters reporting excitability and conjunctivitis. There were no spray-season workers with DEP values reporting convulsions. The high value represented 7 spray-season workers, and the low value represented 14 harvesters.

The mean values for DETP range from a high of 0.38 ppm among spray-season workers reporting no disorientation, excitability, muscle twitching, muscle tremor, or excessive sweating, to a low of 0.05 ppm among harvesters reporting dizziness and blurred and/or dark vision. The high value represents 105 spray-season workers, while the low value represents 5 harvest-season workers. There were no spray-season workers with DETP values reporting convulsions.

The mean values for DEDTP range from a high of 0.42 ppm among spray-season workers reporting muscle tremor to a low of 0.04 ppm among harvesters reporting disorientation, excitability, and muscle tremor. The high value represented five spray-season workers, and the low value represented two harvesters. There were no spray- or harvest-season workers with DEDTP values reporting convulsions, and no harvesters reporting dizziness, muscle weakness, conjunctivitis, and blurred and/or dark vision.

DISCUSSION AND CONCLUSIONS

The findings of this study are complicated by the cross-sectional approach, since follow-up as described by Krause et al. (1981) was not possible. However, the findings are enhanced, as suggested by Maddy (1976), by the rather large number of fieldworkers selected over several sample sites throughout the entire citrus-growing region of Florida.

This approach provided us the opportunity to measure dialkyl phosphate values in the urine of workers during the course of their usual work activity and what may reasonably be assumed to be their normal occupational exposure to pesticides. We did not experience any significant degree of difficulty in communicating with the participants, since most were English-speaking; however, we did take the precaution of having interpreters (Spanish, Creole) available as necessary. There is little doubt that the nominal fee paid the participants increased participation and made it less difficult than others (Krause et al., 1981) have reported to get substantial numbers of samples for analysis.

It seems clear from the mean values shown in Table 1 that a majority of the workers in both the spray and harvest seasons are absorbing OPs. It would appear that the greatest absorption is reflected in the DEP and DETP metabolites. This is to be expected, since ethion is one of the most frequently used pesticides on Florida citrus (Griffith and Duncan, 1983) and DEP and DETP are the primary dialkyl phosphate metabolites for that chemical (Davies et al., 1980).

Based on the DEP mean values shown in Table 1, and on overall mean values of 0.41 ppm and 0.09 ppm for DEP for spray- and harvest-season workers (Griffith and Duncan, 1985b), respectively, it would appear that, as expected, spray-season workers are most heavily exposed to OPs. However, there appears to be no association between the level of urinary metabolites and reported symptomatology. To test the association of the symptoms with residues, we related actual levels of the residues among those with symptoms, to levels in those without symptoms. When metabolite mean values were compared within group—i.e., spray-season workers with symptoms compared to asymptomatic spray-season workers—the mean values were not significantly different. It should be noted that the comparisons among means are based on standard errors as discussed in the methods section and are appropriate, although the standard deviations appear to be large. Odds ratios were computed by tabulating subjects by presence or absence of a symptom versus the presence or absence of detectable levels of residues. The only significant odds ratios were 2.65 for blurred and/or dark vision and DEP ($\chi_2 = 3.35$, $p < 0.03$, one-tailed) and 9.83 for blurred and/or dark vision and DMTP ($\chi_2 = 11.04$, $p < 0.001$, one-tailed) among harvest workers. It is recognized that multiple comparisons were made, and if the Bonferroni

TABLE 2. Comparison of Urinary Alkyl Phosphate Residue Values in Florida Citrus Fieldworkers by Presence or Absence of Selected Disease Symptoms

Symptoms	DMP		DMTP		DMDTP		DEP		DETP		DEDTP		Total	
	S[b] (332)	H[b] (264)	S (323)	H (262)	S (331)	H (265)	S (332)	H (265)	S (331)	H (262)	S (331)	H (262)	+	−
Disorientation	−	+	−	+	+	+	−	+	−	−	−	−	5	7
Dizziness	+	+	+	−	+	+	+	+	−	−	−	0	7	4
Excitability	+	+	+	−	−	−	−	−	−	+	−	−	4	8
Convulsions	0	0	0	0	0	0	0	+	0	+	0	0	2	0
Muscle Twitching	+	−	+	−	+	+	−	+	−	+	+	+	8	4
Muscle Tremor	−	+	−	+	−	−	+	+	−	+	+	−	6	6
Muscle Weakness	−	0	−	0	−	0	+	+	−	+	−	0	3	5
Conjunctivitis	+	+	−	−	−	−	+	−	−	−	+	0	4	7
Blurred and/or Dark Vision	−	+	−	−	−	+	−	+	−	−	−	0	3	8
Excessive Sweating	−	+	+	+	+	−	−	−	−	−	−	+	5	7
Total														
+	4	7	4	3	4	4	4	7	0	5	3	2	47	
−	5	1	5	5	5	4	5	3	9	5	6	3		56

[a] When fieldworkers with symptoms had higher mean residue values than asymptomatic fieldworkers, plus was recorded; minus was recorded when fieldworkers with symptoms had lower mean values than asymptomatic workers. Zero indicates that the numbers did not meet the criteria for statistical analysis. Statistics with zero and trace values excluded.

[b] S, spray-season fieldworkers, number in parentheses.
H, harvest-season fieldworkers, number in parentheses.

procedure were followed, each statistical test should be performed at approximately the 0.0003 probability level for an overall 5% error rate. However, because of the very few statistical differences found, the actual uncorrected probability levels are shown here.

As shown in Table 2, the use of the sign test would appear to show no consistent patterns of aggregation of symptoms by residues. The data as presented would tend to support the suggestion of W. H. Hayes, Jr., et al. (1957) that the occurrence of three or more of the selected symptoms would be more representative of pesticide intoxication, since the individual symptoms commonly occur as a result of conditions other than organophosphate exposure. In this study, the number of people reporting even single symptoms was small, and when the responses were grouped into two or more symptoms the numbers were too small for analysis.

In summary, we were able to determine that citrus fieldworkers are exposed to OPs at levels that have been characterized as high exposure by Davies et al. (1976). However, our data indicate that illness resembling mild poisoning was not significantly more common in persons with higher levels of urinary metabolites. In fact, workers with higher levels frequently had fewer symptoms than the less exposed workers.

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